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# SPECIALIZED AGRICULTURAL WEATHER GUIDANCE FOR KENTUCKY

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## 1. INTRODUCTION

The Techniques Development Laboratory (TDL) has developed objective weather guidance for 15 agricultural locations in Kentucky (Fig. 1). The guidance consists of maximum (max) and minimum (min) air temperatures and max and min 4-inch soil temperatures (under grass) for projections out to 60 hours. Also included in the package are forecasts of minimum relative humidity and precipitation amount probabilities out to 48 hours. The complete agricultural forecast package is valid during the growing season of April through November.

## 2. METHOD

All the prediction equations were developed by use of the Model Output Statistics (MOS) technique (Glahn and Lowry, 1972). This technique consists of determining statistical relationships between local weather observations (predictands) and the output of numerical models (predictors). A forward stepwise selection procedure was used to derive the multiple linear regression equations. The equations were limited to 10 predictors, with each predictor entering an equation being required to reduce the variance by at least one tenth of one percent.

We used 0000 GMT cycle output from the Limited-area Fine Mesh (LFM) model (National Weather Service, 1978) to develop all the prediction equations. Some of the LFM fields were space-smoothed over 5 or 9 grid points in order to reduce the effects of small-scale noise inherent in numerical output. The LFM forecasts were then interpolated from the grid points to the location of each station.

The variables available to the regression program as potential predictors of air and soil temperature, relative humidity, and probability of precipitation amount (PoPA) included 1000-, 850-, 700-, and 500-mb temperatures, dew points, and dew point depressions; 1000-, 850-, and 500-mb heights; 850- and 500-mb winds; 1000-850 mb and 1000-500 mb thicknesses; 850- and 500-mb relative vorticities; 500-mb vorticity advection; 750-mb vertical velocity; 1000-mb height change; K- and total totals stability indicies; mean relative humidity; precipitable water; precipitation amount; and surface temperature. We also screened several trigonometric functions of the day of the year.

The max and min air and soil temperature, and min relative humidity predictands were observations taken for 24-h periods, generally ending about 6 p.m. local time. The PoPA predictands were the occurrences of greater than or equal to .01, .10, .25, .50, and 1.00 inches of precipitation in the same 24-h periods.

For purposes of comparison, we also developed climatic forecast equations for all of the predictands. In these, only trigonometric functions of the day of the year were used as predictors. The forecasts produced by these equations represent the expected climatic value for each day of the year.

In addition, for each of the predictands, we developed equations based on persistence from the previous day. For the air and soil temperature and relative humidity equations, we used the observed value of each element from the previous day as the only predictor. For each PoPA equation, the observed precipitation amount was used as the only predictor.

We developed all the equations from observations taken during April through November, 1976-78; and April through June, 1979. These months (April-November) correspond to the approximate growing season for Kentucky. For the air and soil temperature and relative humidity predictands, we developed a separate equation for each of the stations. For PoPA, we grouped the data for all stations and developed generalized-operator equations valid for the entire state.

## 3. DEVELOPMENTAL RESULTS

Table 1 lists the developmental standard errors of estimate for all the air and soil temperature and relative humidity equations. For air temperature and relative humidity, the MOS equations were better than either the persistence or climatic equations. For the MOS air temperature equations, the standard errors ranged from 3.5 $^{o}$F for the max during the 0-24 h period to 4.1 $^{o}$F for the min during the 48-72 h period. The standard errors for the min relative humidity estimates ranged from 11.1 percent for the 0-24 h period to 11.7 percent for the 24-48 h period.

In contrast, the persistence equations estimated the max soil temperature during the 0-24 h period and the min soil temperature during the 24-48 h period better than either the MOS or climatic equations. For the 24-48 h max and 48-72 h min soil temperature, the MOS equations gave the best estimates.

Table 2 lists the developmental results for the PoPA equations. Brier scores--defined to be one half the score proposed by Brier (1950)--are given for each of the forecast categories. For both forecast periods, the Brier scores of the MOS equations were consistently better (lower values) than those for the persistence or climatic estimates.

## 4. MESSAGES AND SCHEDULES

Agricultural weather guidance for Kentucky is transmitted daily to the Central Region on the overlay circuit at approximately 0700 GMT. Figure 2 shows a sample portion of the new AXUS53 teletype bulletin which contains this guidance. The station abbreviations used in the bulletin are listed in Table 3.

Values of air and soil temperature guidance in the message are rounded to the nearest whole degree Fahrenheit. Values of relative humidity are in percent. The PoPA guidance is in tens of percent with the numbers from left to right in the teletype bulletin being the probability of greater than or equal to .01, .10, .25, .50, and 1.00 inches of precipitation, respectively.

All the guidance is valid for 24-h periods ending at approximately 6 p.m. local time. Dates and times given at the beginning of each bulletin should be used to identify the valid time period for each of the forecasts. Max air and soil temperature, min relative humidity, and PoPA forecasts are listed under the date and time corresponding to the end of the period for which they are valid. Min air and soil temperature forecasts are listed at the midpoint of their valid period.

## 5. OPERATIONAL CONSIDERATIONS

Forecasters using Kentucky's agricultural weather guidance are reminded that all of the forecasts are valid for 24-h periods ending at 6 p.m. Consequently, the forecast elements (such as max air temperature) may occur during either of two calendar days. Also, because excessive amounts of precipitation are rare, it is unlikely that the PoPA equations will forecast high probabilities for the large amount categories, especially at the longer range projection.

Our developmental results for soil temperature indicate that the field forecaster should consider stored soil heat, soil moisture, and past errors in the MOS guidance when issuing soil temperature forecasts. This is particularly important for early projections where a forecast of persistence is often better than the raw MOS guidance. However, previous studies (Jensenius and Carter, 1979; and Jensenius et al., 1978) have shown that if the MOS soil temperature forecasts are modified by subtracting the average error for the past three MOS forecasts, the modified forecasts become better than those based on persistence.

## 6. ACKNOWLEDGEMENTS

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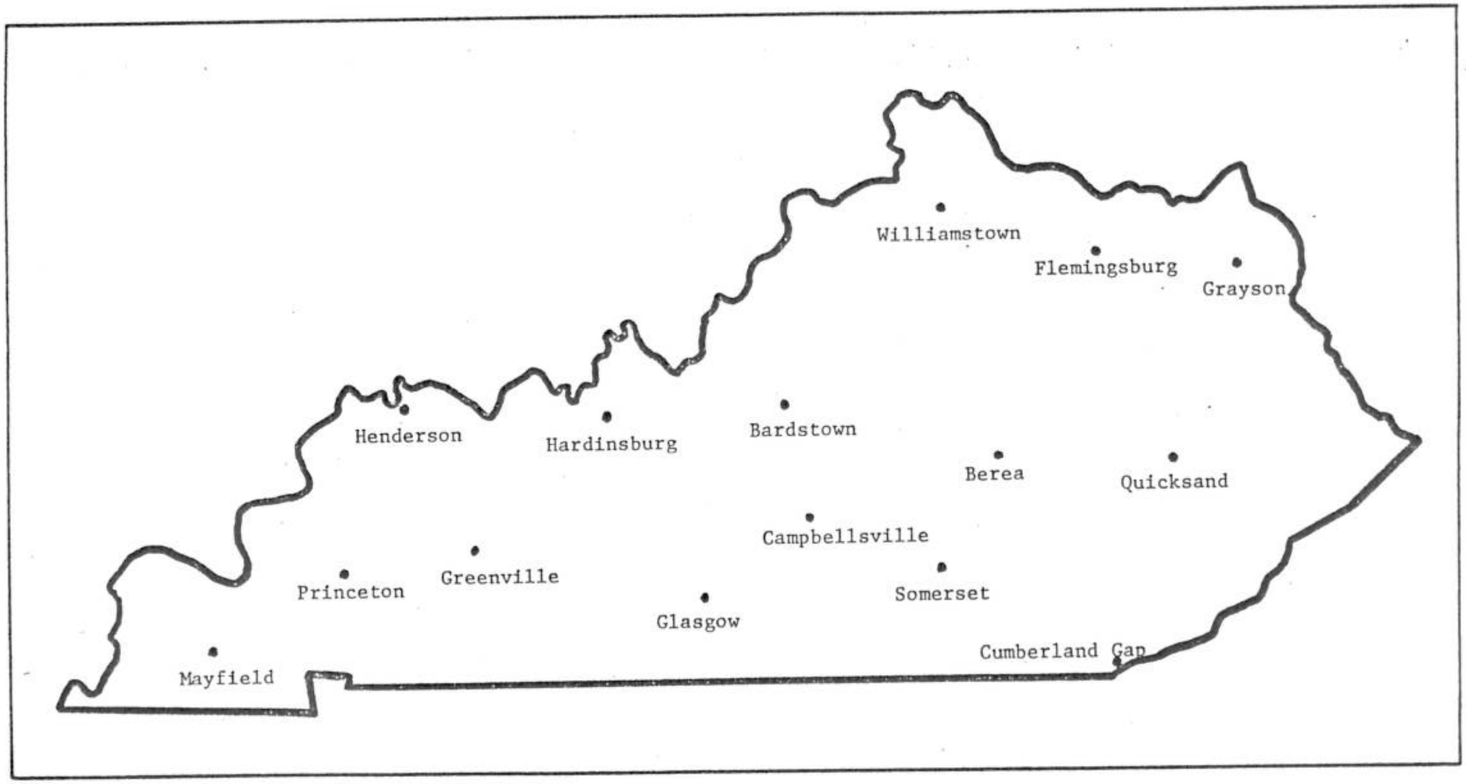


Figure 1. The 15 agricultural stations in Kentucky for which specialized weather guidance is available.

```
AXUS53 KWBC 150000
 AG WEATHER MOS GUIDANCE     4/15/78  0000 GMT  KENTUCKY
                DATE  16    16    17    17
                 GMT  00    12    00    12

BARD AIR    MX/MN  58    37    61    48
     GRASS  MX/MN  55    49    54    49
     RH     MN     42          47
     POPA 24HR 32100        76531

BERE AIR    MX/MN  62    43    65    50
     GRASS  MX/MN  57    49    56    50
     RH     MN     45          52
     POPA 24HR 32100        76531

CUMB AIR    MX/MN  68    45    69    53
     GRASS  MX/MN  58    54    60    55
     RH     MN     39          50
     POPA 24HR 31100        86421

GLAS AIR    MX/MN  70    48    73    55
     GRASS  MX/MN  62    58    64    59
     RH     MN     30          47
     POPA 24HR 21000        53200
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Figure 2. Sample portion of the AXUS53 teletype bulletin.

Table 1. Average developmental standard errors of estimate for the MOS, persistence, and climatic air and soil temperature and relative humidity equations. Errors for the temperature equations are in $^{o}F$ while those for relative humidity are in percent.

| Type of Equation | Approximate Forecast Projection (hours from 0000 GMT) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 0 - 24 | | | 24 - 48 | | | 48 - 72 | | |
| | MOS | Pers. | Clim. | MOS | Pers. | Clim. | MOS | Pers. | Clim. |
| Max Air Temp. | 3.45 | 5.91 | 7.50 | 3.95 | 7.80 | 7.50 | - | - | - |
| Min Air Temp. | - | - | - | 3.63 | 6.95 | 8.18 | 4.07 | 8.88 | 8.18 |
| Max Soil Temp. | 2.57 | 2.01 | 3.62 | 2.62 | 2.64 | 3.62 | - | - | - |
| Min Soil Temp. | - | - | - | 2.44 | 2.24 | 3.69 | 2.51 | 2.90 | 3.69 |
| Min Rel. Hum. | 11.1 | 14.0 | 16.0 | 11.7 | 15.8 | 16.0 | - | - | - |

Table 2. Average developmental Brier scores for the MOS, persistence, and climatic PoPA equations.

| Type of Equation | Approximate Forecast Projection (hours from 0000 GMT) | | | | | |
|---|---|---|---|---|---|---|
| | 0 - 24 | | | 24 - 48 | | |
| | MOS | Pers. | Clim. | MOS | Pers. | Clim. |
| Probability of $\geq$ .01 inches | .121 | .203 | .211 | .131 | .212 | .211 |
| Probability of $\geq$ .10 inches | .104 | .167 | .171 | .114 | .173 | .171 |
| Probability of $\geq$ .25 inches | .087 | .132 | .135 | .096 | .135 | .135 |
| Probability of $\geq$ .50 inches | .065 | .088 | .089 | .071 | .088 | .087 |
| Probability of $\geq$ 1.00 inches | .032 | .036 | .037 | .033 | .036 | .037 |

Table 3. The four-letter abbreviations used for agricultural stations in Kentucky.

| | |
|---|---|
| BARD | Bardstown |
| BERE | Berea |
| CUMB | Cumberland Gap |
| GLAS | Glasgow |
| GRAY | Grayson |
| GREE | Greenville |
| HEND | Henderson |
| HARD | Hardinsburg |
| MAYF | Mayfield |
| QUIC | Quicksand |
| SOME | Somerset |
| WILL | Williamstown |
| CAMB | Campbellsville |
| FLEM | Flemingsburg |
| PRIN | Princeton |